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VISCOSITY OF POLY-ELECTROLYTES*

By RAYMOND M. FUOSS†

Polyelectrolytes are electrolytes of high molecular weight which are derivable from a (sometimes hypothetical) simple monomeric unit. Proteins, polysaccharides, and nucleic acids are familiar examples of naturally occurring polyelectrolytes. (It might be mentioned that the definition is designed to exclude colloidal electrolytes such as oxide sols, in which the conducting unit is a massive charged particle of fixed geometry.) Sodium polyacrylate is a typical synthetic polyelectrolyte containing a polyanion; addition of alkyl halides to polyvinyl-pyridine gives a polyelectrolyte containing a polycation.

When the polyelectrolyte has a chain structure, as in the synthetic materials just mentioned, the configuration of the molecule in solution can be expected to change with concentration. If we consider a very dilute solution of sodium polyacrylate, for example, intramolecular electrostatic repulsion between the carboxyl groups of a given molecule will cause the flexible carbon chain of the polyanion to extend itself to give a rod-like molecule. The solution exhibits one marked contrast to a dilute solution of a simple electrolyte such as sodium chloride. In the latter, an exploring element of volume (of dimensions large compared to interionic distances but small compared to the total volume) contains, on an average, equal numbers of positive and negative ions, and the ionic concentration in it is, within small fluctuation terms, equal to the total number of ions present divided by the total volume. In a polyelectrolyte, an entirely different situation obtains. Due to the structure of the polyion, the charges in the chain can diffuse no further apart than is permitted by the maximum extension of the chain. Hence, at *all* stoichiometric concentrations, however low, violent fluctuations in charge density will be encountered by the exploring element of volume. In the vicinity of a polyion, the corresponding charge density will always be high, while in the regions of the solution between polyions, only counter ions will be found. The polyion thus behaves like a droplet of concentrated solution, regardless of the bulk concentration.

The effect of the above distribution on configuration can best be followed by considering what happens when the dilute solution is concentrated. Interionic distances between polyions decrease, and, due to the high charge density in each polyion, counter ions will be attracted to the chains by coulomb forces. The resulting structure will have a lower net charge than the hypothetical, completely dissociated, chain electrolyte, and, as a consequence of the partial neutralization of the internal charge by counter ions, the chain molecule will begin to curl up under the influence of thermal motion. In other words, as stoichiometric concentration is increased, the polyions will change from extended rod-like configurations to coiled configurations similar to those exhibited by ordinary polymers like polystyrene in solution.

These qualitative statements may be followed experimentally by means of viscosity measurements. Debye has proposed that the ratio of specific volume to concentration is a measure of the volume occupied by chain molecules in solution. For polyelectrolytes, we find that the reduced viscosity is very large (much larger than that of the uncharged parent polymer) in dilute solution, and that this value decreases as we go to higher concentrations. This result may be interpreted as hydrodynamic evidence for the curling of the polyions, as intramolecular repulsion is neutralized due

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to association of counter ions to the chain ions under the influence of electrostatic attraction. Data on a variety of aqueous and non-aqueous systems show that the phenomenon is general. Furthermore, systematic variations in the constants of the corresponding (empirical) viscosity function with the dielectric constant of the solvent support the theory that the viscosity changes are controlled by electrostatic forces.

By addition of simple electrolyte to polyelectrolyte, the theory may be tested further. We would expect that an excess of simple electrolyte would provide an adequate reservoir of counter ions to permit essentially complete neutralization of the charge on the polyions. As a consequence, the chains would contract, due to mutual attraction of ions of opposite charge in each polymeric molecule, much as a crystal of sodium chloride is stabilized by internal attraction. Experimentally, we find that the viscosity of a polyion in the presence of an excess of simple electrolyte is reduced far below that of the parent molecule. Moreover, the limit reached depends on the size of the counter ion and is independent of the ion of like charge. Data have been obtained in both aqueous and non-aqueous systems, which follow the pattern just described.

As a further example of the effects of coulomb forces on the hydrodynamics of polyelectrolytes, let us consider the effect of the addition of hydrogen chloride to a dilute solution of polyvinylpyridine in anhydrous methanol. The polymer is electrostatically neutral and behaves much like polystyrene, except that it is a weak base. If we add a little hydrogen chloride, some of the pyridine groups in the polymer are converted to pyridonium ions. Their mutual repulsion causes the coils to expand, and we observe a rapid increase in viscosity. As more hydrogen chloride is added, this increase continues, until we reach the saturation limit determined by the pK of the base. Subsequent addition of hydrogen chloride now decreases the viscosity, due to association of the excess counter ions with the chain ions, in just the same way as the addition of excess potassium bromide depresses the viscosity of polypyridonium bromide solutions. In other words, a plot of reduced viscosity against ratio of hydrogen chloride to nitrogen shows a maximum. The height and location of the maximum depends, naturally, on the total initial concentration of polymer.

As a final example of the strong electrostatic effects in polyelectrolytes, it has been observed that polycations precipitate polyanions at concentrations as low as ten-millionth normal (less than 0.1 ppm by weight). Both light-scattering work and gravimetric analyses show that these precipitates are not stoichiometric. Rather, they depend in a predictable way on the sequence of addition and on the relative concentration of the two polyelectrolytes concerned.

SECTION OF GEOLOGY AND MINERALOGY

THE GRANITE PROBLEM IN THE HUDSON HIGHLANDS*

By KURT E. LOWE†

The Granite Problem. It would be more exact to speak of problems in the plural, since many aspects of the formation of granites are still controversial. The fundamental issue is the origin of the granite magma or granite-forming fluid about which there is the least knowledge and the most conjecture. Other problems involve mode of emplacement, age relations, megascopic and microscopic structure of granites. The principal controversy, however, which

* This paper, illustrated with lantern slides, was presented at the meeting of the Section, November 7, 1949.

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has engaged geologists for more than half a century, deals with the formation of granites in the environment in which we now find them. Two opposing schools of thought have developed:

(1) The "magmatic" (traditional) school believes that granites are formed by intrusion of a true melt or magma of granitic composition into the rocks of the earth's crust.

(2) The "granitization" (relatively modern) school maintains that granites are the result of transformation of pre-existing rocks in place. Granitization, here used in its broadest sense, includes, according to Grout,[2] "a group of processes by which a solid rock (without enough liquidity at any time to make it mobile or rheomorphic) is made more like granite than it was before, in minerals or in texture and structure, or both." This may be accomplished by emanations from an igneous source penetrating the rocks of the solid crust either in the form of hot, aqueous solutions (hydrothermal) or as gases (pneumatolytic). Ionic transfer in the solid state has also been proposed as a granitization process, but seems to be as yet little more than a theoretical concept lacking reliable criteria for recognition in the field.

Most proponents of granitization favor hydrothermal solutions as "granitizing agents" involving the process of metasomatism, which was defined by Lindgren[3] as "an essentially simultaneous, molecular process of solution and deposition by which in the presence of a fluid phase, one mineral is changed to another of differing chemical composition."

It is the purpose of this paper to discuss the field evidence on granites obtained by the writer in the Hudson Highlands and to examine it in the light of the two schools of thought.

The Hudson Highlands. The Highlands are a chain of low, but rugged, mountain ranges extending about 140 miles from Reading, Pennsylvania, northeastward through northern New Jersey and southeastern New York into western Connecticut. They are mostly Precambrian crystallines, representing an ancient orogenic belt of Grenville(?) sediments which were folded, faulted, metamorphosed, and invaded by several igneous phases.

The Hudson Highlands, a rather loose geographical term, refers to that portion of the mountain chain which lies athwart the Hudson River in New York State. Berkey and Rice[1] mapped the West Point quadrangle and provided the first comprehensive treatment of Highlands geology on both sides of the Hudson River. The writer's studies have been confined to the region west of the Hudson River (Schunemunk quadrangle), with particular emphasis on detailed work in the Bear Mountain area at the southeastern gateway of the Hudson gorge.

Regional Structures. The folded structure of the Highlands is clearly indicated by the topography of the Bear Mountain region (FIGURE 1). Ridges of resistant Storm King granite, which is conformable with the structure of the country rocks, depart from their predominant northeasterly trend (Stockbridge and Long Mountains and Holmans Hill, or the Crown Ridge and Bare Rock). The trends of Turkey Hill, Summer Hill, West Mountain, The Timp, and Dunderberg (the last two not shown on map) describe a distinct arcuate pattern with Bear Mountain as the center. Field measurements proved the existence of a large, synclinal structure with a northeast plunge of 40° at Bear Mountain, steepening rapidly to 50° and 60° at Fort Montgomery.

The major, probably Precambrian, faults (FIGURE 1) strike northeast, *i.e.*, parallel to the tectonic trend, and indicate overthrusting to the northwest. The more northerly strike of the prominent Timp Pass-Hudson River fault (north of Doodletown Brook) suggests possibly Paleozoic origin (Taconic or Appalachian). Overthrusting along this fault is believed to account for the absence of the eastern limb of the Bear Mountain syncline and for intense crumpling, shearing and, overturning of minor folds in the Bear Mountain Inn-

FIGURE 1. Hudson Highlands in the vicinity of Bear Mountain, N. Y.

Doodletown area (thrust sole). Cross faults at Highland Brook, Popolopen Creek, and Hell Hole are interpreted as high-angle tear faults with large vertical components of displacement.

Hudson Highlands Granites. Two major granite types can be distinguished. The older Canada Hill granite phase includes the Mahopac, Reservoir, and Canada Hill granites of Berkey and Rice.[1] This Precambrian granite is conformable with the Grenville(?) metasediments and contains quartz, albite-oligoclase, perthite, and variable quantities of biotite. Synkinematic origin is indicated by secondary foliation concordant with the structure of the folded metasediments and plastic deformation (boudinage) structures of the pegmatitic facies.

The younger Storm King granite is postkinematic and of uncertain age. Microcline-microperthite is the dominant feldspar and hornblende the dark mineral. Quartz content varies from 5 to 30 per cent by volume. It is entirely conformable with the structure of the Highlands Complex, a term used by the writer to include all Highlands crystallines of pre-Storm King age.

Canada Hill Granite Phase. The most typical representative is a medium-grained, medium-gray, biotite granite with faint to excellent foliation depending on the quantity of biotite present. East of the Hudson River, it occurs in large masses (Anthonys Nose and Canada Hill) and was interpreted by Berkey and Rice[1] as the result of intrusion of a "highly reactive and insidious magma of bathylithic proportions." The authors, however, also mentioned the effects of "mineralizers and emanations in a very fluid condition at high temperature and pressure." Thus, both magmatic emplacement and metasomatism were believed to have been responsible for the formation of this granite.

The Canada Hill granite phase at Bear Mountain appears to be represented only by granitic layers intercalated with the metasediments (biotite, hornblende, and augite gneisses; biotite, graphite, and epidote schists; and graphitic marbles). Several such layers are exposed along the Perkins Memorial Drive (southwest flank of Bear Mountain; below Storm King granite contact) and can be traced some 600 feet along the strike. They have quite constant thickness and their contacts with the intervening dark gneisses and schists are sharp. Some are remarkably uniform, medium-grained, quartz-feldspar rocks with discontinuous pegmatitic stringers oriented parallel to the layered structure. The writer has called these rocks "pseudo-alaskites," since their intrusive origin is questionable. Microscopic features, such as intimate intergrowth of highly poikilitic feldspars, and extensive replacement of quartz by feldspars seem to be the result of metasomatism and recrystallization.

Other layers contain sufficient biotite to make the rocks indistinguishable from the typical Canada Hill granite of Berkey and Rice[1] in hand specimen and under the microscope. Also, there are no dikes or offshoots from these granitic layers into the adjoining fissile metamorphics, as one might expect had these rocks been introduced as a magmatic melt.

The evidence then points to some process of selective reworking of sediments (possibly rather pure arkosic sandstones) in place by hydrothermal solutions, rich in alkalies.

Storm King Granite. This youngest granite of the Hudson Highlands has remarkably uniform structure and composition, which make it the most distinct lithologic unit in this terrane of complex rocks. The typical Storm King granite is a medium- to coarse-grained rock, dull gray on fresh exposures, but sometimes with a greenish to pinkish tinge and somewhat greasy luster. Exfoliation is prominent, and the residual mantle has a "rubbly" character.

Linear parallelism of prismatic hornblende crystals and crystal aggregates is characteristic and gives the rock a streaky, gneissoid appearance on most exposures. This linear structure has a constant orienta-

tion of N.40°E.40°, or nearly parallel to the tectonic axis of the Bear Mountain syncline (FIGURE 1). In the marginal portions of the granite mass, the linear hornblende elements commonly acquire an additional plane-parallel alignment. Such platy or planar structure has invariably the same attitude as the nearest granite contact surface (FIGURE 1).

At Bear Mountain, this granite occupies the core of the syncline (maximum thickness: 3000 feet) and extends in sheetlike fashion along its western limb, forming the continuous ridge crests of The Torne, Crown Ridge, and Bare Rock (FIGURE 1). Contact exposures aggregating some 5000 feet prove that the granite mass is entirely concordant with the structure of the Highlands Complex. Contacts are sharp and show no gradational transition. Xenoliths of the country rocks are found only in the near-contact portions of the granite. They generally maintain the same structural attitude as the adjacent parent rocks and exhibit sharp, angular borders without any evidence of fusing.

Primary joints are filled with aplite, quartz, and epidote and coated with chlorite and sericite. The coarse-textured pegmatite facies of the Storm King granite is characteristically pink and quartz-rich and contains large, unoriented hornblende crystals. Several such pegmatite bodies within the granite mass have indistinct, gradational margins and centers of graphic intergrowth between potash feldspars and quartz. Storm King pegmatite dikes are not uncommon in the Highlands Complex, but only in one instance could a dike be observed cutting across the granite contact.

Certain distinct mineralogical changes occur in the granite near contacts with the Highlands Complex. Composition of this contact facies seems to be related to the lithology of the adjacent country rocks. Increasing quantities of biotite, graphite, garnet, and plagioclase feldspars are usually present near contacts with basic Grenville (?) gneisses and schists. Where Storm King granite is next to granitized metasediments (Canada Hill phase), its contact facies seems to be characterized by lack of dark constituents, increase in potash-soda feldspars (perthite), and abundance of quartz.

Petrofabric study revealed that quartz grains in the interior of the Storm King granite mass have no clearly preferred space-lattice orientation. There is certainly no evidence of a tectonic pattern of orientation of the quartz *c* axes as stipulated by Sander[7] for fusion tectonites.

Emplacement of Storm King Granite. The evidence cited appears to be in favor of magmatic intrusion of Storm King granite in the form of a synclinal pluton following the pre-existing structure of the Highlands Complex. Linear and platy mineral structures are interpreted as due to magmatic flow which caused parallel orientation of early hornblende crystals in the viscous melt. Rather uniform lithology, sharp contacts, shape, and position of xenoliths serve as corroborating evidence. Magmatic segregation would account for the gradational pegmatite bodies within the intrusion, and the contact facies can be explained by reaction of the magma with its wall rocks. The most probable source of the primary joint fillings was hydrothermal end-stage activity of the magma.

Postkinematic nature of the intrusion is indicated by complete absence of secondary foliation and lack of preferred (tectonic) orientation of quartz space-lattices. Since this sizable granite pluton was evidently the result of quiet intrusion at depth and under no great deformational stress, it is unlikely that it made room for itself by lifting the overlying country rocks. It is suggested, therefore, that gradual sagging of the synclinal structure under plastic conditions into the emptying magmatic chamber below created space in the more solid rocks above, which in turn was occupied by the rising magma. This concept of "exchange of space" was first proposed by Loewinson-Lessing[4] to explain the emplacement of large, gently dipping trap sheets in Siberia.

Age Correlation and Origin of the Highlands Granites. In the Hudson Highlands, the

Storm King granite is unquestionably younger than the Canada Hill granite phase, which is believed to be Precambrian. In the absence of radioactive age determinations, the Storm King granite could be Paleozoic as far as the available record goes. About 12 miles southwest of Bear Mountain, this granite disappears as a recognizable intrusive unit, and mixed granite gneisses take its place, suggesting formation by granitization rather than magmatic intrusion. The Byram and Losee granite gneisses of New Jersey and Pennsylvania, which were correlated by Berkey and Rice[1] with the Storm King and Canada Hill granites, respectively, appear to be of nearly the same age, because they have been found cross-cutting each other.

This age discrepancy and somewhat differing mode of formation of the principal granitic phases in these two contiguous sections of the Highlands may be simply a function of the regional structure. The continuous, tectonic structure of the Highlands has a consistent northeast plunge. Thus, the crystalline rocks of the Hudson Highlands represent a younger stratigraphic horizon than those of New Jersey and Pennsylvania. Both granites probably originated from a single magmatic source, in view of their very similar chemical composition, which differs to any extent only in the potash-soda ratio. In the southwestern Highlands, granites were formed at the greatest depth, *i.e.*, under greatest pressure and temperature. In such environment the magmatic fluid was probably very liquid, mobile, and chemically active, since it still contained all its volatile constituents, and therefore was particularly well suited to act as "granitizing agent."

The most volatile and reactive components (soda-rich in this case) then penetrated the upper rock horizons, causing formation of the Canada Hill granite phase by metasomatism. At the same time, the viscosity and chemical stability of the residual liquid gradually increased, with loss of the volatiles, until a true magmatic melt had formed. With increasing viscosity, this (potash-rich) magma intruded ever more slowly into the higher levels of the crust to form the Storm King granite.

In conclusion, it might be suggested that the opposing camps of "granite makers" are not nearly as far apart as they would have us believe. It is quite plausible that granitization and magmatic intrusion are merely phases of one and the same process and depend largely upon the crustal horizon at which the formation of a granite takes place.*

References

1. Berkey, C. P. & M. Rice. 1919. Geology of the West Point quadrangle. Bull. N. Y. State Mus. 920.
2. Grout, F. F. 1941. Formation of igneous-looking rocks by metasomatism: A critical review and suggested research. Bull. Geol. Soc. Am. **52:** 1525–1576.
3. Lindgren, W. 1925. Metasomatism. Bull. Geol. Soc. Am. **36:** 247–261.
4. Loewinson-Lessing, F. 1933. Über die Raumbildung grosser flacher Intrusivlager. Min. Petr. Mitt. **43:** 271–282.
5. Lowe, K. E. 1947. Storm King granite at Bear Mountain, New York (abstract). Bull. Geol. Soc. Am. **58:** 1203–1204.
6. Lowe, K. E. 1948. The granite problem in the Hudson Highlands. Guidebook of excursions, 61st annual meeting, Geol. Soc. Am. 43–45. With W. H. Bucher, 46–50.
7. Sander, B. 1934. Petrofabrics (Gefügekunde der Gesteine) and orogenesis. Am. Jour. Sci. **28:** 37–50.

* A detailed and documented treatment of the subject matter discussed in this paper will appear under the title "Storm King Granite at Bear Mountain, New York" in the Bulletin of the Geological Society of America, February or March, 1950.

SECTION OF BIOLOGY

EFFECT OF IONIZING RADIATIONS OF GAMETES, EMBRYOS, AND THE NEWBORN*

By ROBERTS RUGH†

Since we are all breathing radon and thoron into our bodies, and since neutrons from cosmic rays are transmuting nitrogen into C^{14} in our bodies at all times, we now admit that we must contend with ionizing radiations as we do with death and taxes. It is true that the total cosmic and gamma radiations to which the average man is subject may be less than 0.3 mr. per day or 0.1 r. per year. This is enough to account for the ionization of about 1 molecule in one hundred billion molecules per year. This doesn't seem like very much, and, biologically speaking, it may never prove to be much. It must be pointed out, however, that 1,000 r. of X irradiation will ionize only about 1 molecule in ten million, and yet this is sufficient to be lethal for most organisms. Biologically speaking, there may be some 10^{10} molecules in the average cell, but only 0.00001 per cent of them need be ionized to cause the death of most cells. From the point of view of the living organism, therefore, we must admit that the effect of ionizing radiations must be better understood.

Ionizing radiations may be divided into two major categories, again speaking biologically. Those which affect the organism from without, or from external sources, are:

Alpha Particles. From polonium, radon, or the bombardment of boron or lithium. The ion density of alpha emitters is very great, but penetrance is very low. That is, the number of ions per cubic millimeter is relatively very great, but no alpha particle can penetrate biological tissues to any great depth; for instance, they cannot get through the outer dead layer of skin.

Beta Rays. Pure sources would be from isotopes of Phosphorus (P^{32}), Sulphur (S^{35}), Carbon (C^{14}), and others. The penetrance of beta rays into tissues is somewhat greater than alpha penetrance, but, at 1 mm. depth, about 60 per cent of beta rays are absorbed by the skin when derived from phosphorus. There are mixed sources of beta rays, combined with gammas, as in sodium, potassium, and iodine.

X Rays. Depending upon whether the X rays are low voltage (soft) or high voltage (hard), there will be different degrees of penetration of any body of tissue. This fact is being used to treat superficial or deep tumors with X rays.

Gamma Rays. These may be obtained from some isotopes, by filtering out the betas, from Radium A, and from other sources. The ion clusters from gamma irradiation are somewhat farther apart than the clusters for even the hard X rays.

Neutrons. These are derived from the pile. The "n" equivalent of the "r" has not been satisfactorily determined against biological material.

The internal sources of ionizing radiations are the various isotopes which may be implanted, injected, or ingested. The broad and exciting field of research and therapy opened up by the discovery of isotopes is not to be discussed here, but it might be pointed out that, from the standpoint of control of irradiation of specific regions (with the exception, possibly, of iodine and metastatic thyroid carcinoma), the isotopes are not yet as easily controlled as the external sources of irradiation. This is due in part to the facts that decay, excretion, and diffusion throughout the body may be somewhat difficult to control and that there are great variations in the type and the energy of particles emitted from the different available isotopes.

Mention should be made of three of the six major theories concerning the biological action of ionizing radiations, not because any one of them is considered satisfactory but rather to point up the fact that

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we are a long way from understanding just what happens when such ionizations are brought about within the cell.

(1) *Enzyme Inactivation Theory.* Recognizing the powerful influence of enzymes in normal metabolism and the fact that so few molecules of a cell need be ionized to knock it out completely, one is tempted to attribute the damaging effects to the inactivation of these vitally important protein enzymes. This theory may be tied in with the fact that the water molecule is so abundant, that it is therefore probably the most frequently ionized molecule, and that it is functional in enzyme activity. This theory of enzyme inactivation has as its supporters such men as Barron, Dale, Rudisill, and Hoch.

(2) *Fluid Flow Theory.* This is the theory of Failla, which states that nuclear and cytoplasmic swelling, which follow irradiation, is due to excessive ionization of molecules peculiar to the cell so that there is an excessive endosmosis. This is plausible as long as we admit that a semipermeable membrane intervenes—a membrane which will not allow egress of many of the newly ionized particles.

(3) *Point Hit Theory.* This is also known as the "target theory" of Lacassagne, Glocker, Lea, Crowther, and others. It implies that within the cell there exist specific sensitive volumes within which ionizations are biologically effective. Any ionization, to be effective, must hit the target volume. Other ionizations could occur within the cell, but they would be ineffectual since they would then concern insensitive volumes.

The first two theories mentioned incorporate the end result within the theory (enzyme inactivation and fluid flow), while the latter tries to explain those end results by postulating differential sensitivities within the cell for which there is some circumstantial evidence. None of these, or other theories, however, as yet explains why the ionization of 1 molecule in 10 million will kill a cell or organism.

[Lantern slides reporting investigations on a wide variety of forms, from amphibia and birds to mice and hamsters, were shown.]

Some of the conclusions which might be drawn from these and other works, are given in the summary which follows.

(1) Ionizations, to be biologically effective, must be absorbed by the living system. Mere exposure is no guarantee of absorption. At high levels, the intensity of irradiation is not as important as is the total dose, but, at low levels, fractionation seems to allow interradiation recovery.

(2) There is insufficient evidence in support of the Arndt-Schulze Law, which states that small doses accelerate, medium doses depress, and large doses destroy.

(3) There seems to be no differential susceptibility of the sexes, apart from their gonads. In most cases (Amphibia seem to be an exception), the ova are more sensitive than the sperm.

(4) Heavier animals, of the same age and species, seem to be the more resistant to irradiation damage.

(5) Multimodal factors appear in death of many forms, suggesting that the mechanisms which bring about the death of an organism may be multiple.

(6) There is always a latent period between irradiation and evidence of the biological aftereffect. The shortest interval of demonstrable effect seems to be four hours, and the longest may be a matter of weeks. Cell damage may occur without any evidence until a subsequent attempt at mitosis is made.

(7) Viruses, bacteria, eggs, and unicellular Protozoa, when irradiated, are affected very differently from a compact multicellular organism, largely because of the reduction in scattering and the lack of accumulated effects.

(8) Even within the lifetime of a single organism (*e.g.*, *Drosophila*) there may be a 500-fold or greater difference in sensitivity to ionizing radiations, depending (at least in part) on the rate of cell proliferation at the time of exposure.

(9) Many environmental factors have been studied for their effect in protecting the organism or enhancing the radiation effect. Some of these are dryness (mois-

ture), oxygen (anerobiosis), temperature, anesthesia, nutrition, *etc.* Factors within the organism such as age, weight, metabolic activity, and rate of germination may all alter the reaction to ionizing radiations.

(10) The "Hertwig" effect (activation without syngamy by X-rayed spermatozoa), which has been demonstrated for the frog and for *Habrobracon*, has not been demonstrated for many higher forms. This may be because defective embryos are generally resorbed during intra-uterine life. In support of this contention is the case of Parkes,[1] in which rabbit eggs inseminated with sperm previously exposed to 25,000 r. X rays proceeded to cleave, though abnormally. As long as sperm are motile, they seem to be able to fertilize eggs, and frog sperm exposed to 120,000 r. X rays will activate normal eggs. The reduction in litter size, when the male mammal is X rayed, is probably due to resorption of damaged embryos.

(11) X radiation of gametes, either sperm or eggs at low levels, has no effect on the rate or pattern of the early cleavages. Irradiation of the zygote is far more damaging than comparable irradiation of either the gamete or the adult. X irradiation of *Arbacia* eggs, prior to fertilization with normal sperm, showed delay in cleavage to an increasing degree as the dose was increased from 10,000 r. to 100,000 r. The cleavage delay at controlled temperatures of 15°, 20°, and 27° C. can be used to determine the biological equivalent of roentgens when using types of irradiation other than X rays.*

* It has thus far been impossible to develop a roentgen equivalent biological as the roentgen equivalent physical (r.e.p.) because (*a*) the whole organism responds in a manner different from its organ parts, (*b*) the organism from the fertilized egg to senescence is not uniformly radio-sensitive, and (*c*) the various tissues, at any stage, are differentially sensitive.

(12) In the adult, the nervous system seems to be one of those most resistant to irradiation damage, while in the embryo this system is the most sensitive. Inhibition of growth, proliferation and desquamation of neuroblasts into the neurocoele, and interference with mitosis are some of the demonstrable effects of X radiation damage on the embryo. It is believed that survival is enhanced as long as the circulatory system remains undamaged. Sensitivity to radiations is reduced as the differentiation of organ systems is achieved, but the newborn seem to be more resistant than the aged.

(13) There is evidence that the isolated (egg) nucleus is less sensitive to X irradiation than when it is surrounded by yolk and cytoplasm.[2] In general, it is believed that the more damaging effects of ionizing radiations are on the nucleus and on its hereditarily influential genes. Cytoplasmic influences are not denied.

Much is known about the chemical effects of ionizing radiations, more is known about their physical effects, but relatively little is known about the biological effects with any certainty except that high exposures are fatal to all living matter. It is the province of the radiobiologist, in close and essential collaboration with the radiochemist and radiophysicist, ultimately to discover exactly why the ionization of one molecule in ten million is enough to interfere with the normal life processes so that death is inevitable in most cells and organisms.

References

1. PARKES, A. S. 1947. Effects on early embryonic development of irradiation of spermatozoa. Brit. J. Radiol. Supp. **1:** 117.
2. DURYEE, W. R. 1939. Does the action of Xrays on the nucleus depend upon the cytoplasm. Biol. Bull. **77:** 326.

SECTION OF PSYCHOLOGY

THUS SPEAKS THE BODY–AN ANALYSIS OF POSTURAL BEHAVIOR*

By FELIX DEUTSCH

Psychosomatic medicine investigates the sources of and motivations for the correlations and interrelations of emotional and bodily behavior. The conclusions from and interpretations of these integrated manifestations are, by and large, the fundamental basis of psychosomatic medicine. They represent the systematized knowledge of "how speaks the body." The study of motor behavior can contribute a great deal to the understanding of the personality from the psychosomatic point of view. For the past 5 years, I have been occupied with posturology, *i.e.*, the study of the unconscious motivations of postural behavior as it can be observed during the psychoanalytic sessions.

Three years ago, in a paper on "The Analysis of Postural Behavior," I expressed the opinion that close observation of the postural patterns of a patient can furnish the analyst with a readily available diagnostic tool, which may give him some clues for the existing psychodynamic process. I suggested that the more acquainted he may be with the basic postural patterns of his patient, the more apparent, significant, and indicative, deviations from this pattern will become to him. I emphasized, however, that the description of postural behavior and the analysis of some components of this behavior, which I had reported, were only a beginning of an attempt to introduce an additional clue to the understanding of unconscious motivation in the analytic settings. At the time of my last presentation, my observations were based on the analysis of 17 persons. In the following two years, 11 more cases could be added. Thus, at that time, I had 28 cases on whom those observations could be made. The procedure followed was to register any postures or changes of postures during every analytic hour and, likewise, the concomitant verbalized material.

It need not be emphasized that only the movements of the head, arms, and legs of the person lying on the couch, apart from the body posture as a whole, had been observed, since the analyst was sitting behind the person. The different postures of every hour were computed in a posturogram, on which the existing positions of the head, of the left and right limbs, and of the body were recorded.

From these posturograms the conclusions which follow can be drawn.

The configurations of the postures are bound to be characteristic for the individual in question. Their appearance will depend on: (1) the firmness of the synthesization of the postural pattern within the personality; (2) whether, during the free associative process, the ego control will be abandoned to such a degree that involuntary movements can break through; (3) the age period to which the individual regresses at a certain moment and the degree of erotogenization and symbolization of the part of the body in question, the number of inhibitory and defensive factors involved in the basic posture which governs the protective postural attitudes, or the need for the expression of the situation and emotional condition through the muscle apparatus of a certain part of the body; (4) the equilibrium between the instinctual drives and inhibitors and the pressure of conflictual instinctual drives which compete for their gratification. It can be stated with great certainty that the posture will change only whenever a shift in the psychologic situation takes place for which another postural expression is needed. The postural behavior substitutes, or sometimes precedes, the verbalization of the conscious material and is the forerunner of the appearance of the repressed unconscious. I assume that the signal to move very likely comes from sub-

* This paper, illustrated with lantern slides, was presented at the meeting of the Section, November 21, 1949.

liminal sensations in the bodily sphere, particularly in the skin.

On one hand, the movements are always in relation to imaginative objects, or, on the other hand, somebody can become the object himself in relation to himself. The number and kind of emerging deviations from the basic posture depend on the existing emotional situation, and they change with the change of the situation. The emerging new postures are all predetermined and are released through the emerging unconscious material

The progress of analysis is very often expressed through the emergence of latent, expressive movements which are connected, by necessity, with verbalized material. These movements substitute preconsciously determined material and are the precursory expressions of an emotional content which was not yet consciously matured. Emerging postures seem to be the product of a long developmental process which very likely has its roots in the earliest childhood, depending on the psychologic development. Some of these postures betray their early origin, many showing an infantile character.

Much can be learned from the postural behavior of the hands and fingers. The postures of the hand seem to be less dependent on and interrelated with other parts of the body. During the analytic hour, three main postural behaviors of the hands can be observed: (1) they can be cupped, the right over the left hand or the left over the right; (2) they can be held in a flat position, not touching each other, more or less close together; or (3) they can be clasped, holding the fingers interlocked or interlaced. The thumb has a specific posture, *e.g.*, either it is covered by the fist or one thumb is cupped over the other or touches the other only with the uppermost joint.

This kind of detailed observation of the hand posture has brought the following conclusion: in accordance with the basic postural behavior of other limbs, there exists a basic hand posture characteristic for every person, *e.g.*, one person might always hold the right hand on top of the left, integrated with certain leg postures. Very often the change of the hand posture is accompanied by a change of the leg. Schilder has already pointed out that a great part of the body is discovered by the hand and that the hand itself is an outside world for those parts of the body which it touches and, vice versa, the body is an outside world for the hands. Parts of the body which can be easily reached by the hand have, therefore, a different psychologic meaning from those parts of the body which can only be reached by the hands with difficulty.

Some time ago, I saw a four-year-old, prematurely born, blind boy who could not talk and could even stand only with great difficulty. He made rhythmic pounding movements of the left hands against the bed, as well as against his own head. It was interesting that, in spells of completely inarticulated outcries, he suddenly turned in a protective attitude with his right hand towards the right ear while he tried with the left hand to attack and tear this ear. It seemed as if the right hand had taken over the protective, defensive attitude, whereas the left hand played the destructive, aggressive role. The boy, who had been frustrated in his relationships towards the outer world and had been deprived of the love of his mother, who rejected him, used his hands on his own body to act out his ambivalent feelings, assigning the positive feelings to the right hand and the negative feelings to the left hand.

An occasional observation of a catatonic patient showed that the arrested movements of his arms and hands were due to a tabooed relationship between certain symbolized and personified parts of the body, which he kept in resistive immovableness to each other. It could be shown, however, that the blockage of movement in his arms or hands was not equally inflicted upon other limbs. Those parts which had less genital representation and less identification with ambivalent objects would be freed more easily from the prohibited interrelationship and given freedom of movement. These arrested move-

ments of different parts of the body suggest that the ego is afraid of the loss of integration, *i.e.*, of separating certain parts of the body from each other, of moving them away from a certain part of the body which has become sexualized or has achieved the role of an external love object.

Since the postural behavior is overdetermined, like most of the psychosomatic symptoms, arrested movement can mean, on one hand, the prohibition of giving in to a sexual impulse, or, on the other hand, the fear of acting out an agressive act. It may also mean a protective attitude against the hostile approach from outside, as well as the exposure to this approach. The flexibility of postural attitude depends on the personification and representation of certain parts of the body and their relationship to each other. Instinctual needs invested in them, with their drives for gratification and with their defensive and protective restraint, determine the attitudinal interrelationship.

It is impressive that, very often, the appearance of preconscious oral tendencies might be revealed almost regularly by a move of one hand to the mouth, either to cover the mouth or to hold the hand suckingly against the lips. During the revival of castration fears, the hands might selectively turn to the forehead, to the nose, to the neck, to the chin, or to the ear, as if in need of protection or as the target of aggression. This selective behavior is by no means a chance reaction and indicates with certainty, when it occurs, the underlying psychodynamic process. It is striking how selectively those hand-head relationships are predetermined and how disguisedly they force their expression.

A patient with severe obsessional neurosis assumed a strange hand-posture throughout her three year of analysis, building the prettiest architectonic edifices with her fingers. Eventually she became conscious that these fingers represented family members—two sisters, a brother, father, and mother—whom she made move as in a puppet show. The aggressive, destructive, and hostile feelings, as well as the friendly positive ones, toward them were acted out in continually changing positions of the fingers of both hands to each other which, according to their personification, played the role given them in the unconscious.

Another example of such predominant and selected use of fingers for the expression of dormant and unconscious strivings is the behavior pattern of a young man with female identification and latent, passive, homosexual tendencies, who always revealed his seductive, feminine phantasies by putting the fingers of his hand unconsciously in a triangular position illustrating the formation of the female genital or anal orifice. From this configuration, he changed back and forth to an interlaced and intertwined finger position, well known in passive dependent persons as the expression of holding symbiotically, so to speak, the feminine and masculine parts together. During a two-and-a-half-year analysis, the feminine hand posture of this patient was interrupted only twice for some time when, in rebellion against the paternal figure and later the brother figure, he reinstituted some of his masculine trends.

A female patient, with strong masculine tendencies, expressed in the hand posture—the right hand on top of the left—the unconscious phantasy of being on top of the male object. A change in the psychodynamic constellation, when feminine tendencies broke through, was accompanied by a change of the hand-posture.

It was interesting that, in a similar case of a strong, masculine-personality pattern of a woman who was left-handed, the masculine tendency was expressed by holding the left hand on top of the right one. The postural configuration changed after she had turned to an acceptance of the feminine role, when she cupped the left hand with the right one.

It is not my purpose here to enlarge on the psychological problem of handedness. I wish to emphasize, however, that preferred laterality is manifested not only by the hands but by all other organs or functions in which two sides can be involved. Thus, we also find preferred laterality in eyedness,

in monocular sighting, in leggedness, and in walking.

The side of cerebral dominance is not inherent nor inherited but is determined by the functional interaction, which means the individual and his environment. The ultimate side of development is a decision which rests with the postnatal functional experience of the individual. This is in complete correspondence with the experiments of Robert Yerkes on chimpanzees. Considering his observations all together and applying them to the human being, we are aware that, in the use of postures of the right and left side of the body, intrinsic and extrinsic factors are involved of which the individual is very often not aware. This is certainly true for the patterned behavior during analysis.

The infant has no laterality preference. He is originally ambilateral. Preferred laterality is a complicated developmental psychologic trait which begins to appear at about nine months. Abram Blau pointed out, from the analytic viewpoint, that the infantile neurosis which leads to negativistic sinistrality appears before the age of 2, and is caused by an unsatisfactory relationship between the child and the mother. He claims that, from the dynamic developmental viewpoint, the sinistral child often develops a rigid, self-willed, obsessive, compulsive, and anal personality structure. In grown-up individuals, sinistrality sometimes may be only a relic of neurosis in the patient.

Many relics of early childhood are transparent in the regressive postural behavior during analysis. They may even indicate the degree of regression. The postural regression may sometimes simulate the very early infantile period, in which the head and neck reflex was still present, *e.g.*, when the arm and leg are both in marked extension and the opposite arm and leg in partial flexion. The tonic neck reflex pattern is a fundamental feature in the mechanics and development of human behavior. Gesell points out that it should be recognized that the tonic-neck reflex behavior pattern is not a stereotyped reflex, but that it is a growing pattern which undergoes progressive changes with the maturity and the economy of the organism. From the standpoint of embryology, all new behavior events have their developmental rules in the old. The tonic neck reflex is, in a broad genetic sense, a movement pattern within which a wide area of postural and high hand coordination are achieved and permanentized. This behavior pattern very often can be recognized in some of the postural behaviors of the adult in the analytic situation. Of course, we meet there only traces of such patterns, but it seems as if the regressive behavior during the analytic situation leads to a regressive postural pattern which has its roots in these early stages of human life, where these patterns became fixed through continual repetition. The mechanism of this repetitivness may be as follows:

All repetitive behavior seems to have its origin in bodily rhythm—apart from the fact that the central nervous system is in a constant state of repetitive neuronal activity. I venture to say that that rhythm can be traced back, as a perceived rhythm, to the earliest rhythm recognized through its sensation, *i.e.*, the rhythm of the heart. The perception of rhythmic breathing movements follows later. The rhythm of the heart represents the most consistent repetitive feeling continually perceived during the whole of life. It might be that repetitive compulsion may stem from these sources. It is well known that any change of the heart rhythm is accompanied by apprehension or anxiety, as if the most secure pillars of the ego were threatened. The child tries to provide its security from the beginning with repetitive acts necessary as a safety device against a loss. As soon as the limbs become integrated into the body-image and become personalized, they are used in their movements toward and away from the body, as a kind of continual check-up on whether the object whose loss is feared is still there. Loss on this early level is always fear of loss of love. The child tries to reassure himself by repetitive movements which can have a compulsive, re-

petitive character. It selects certain parts of the body for a partial identification with love objects like mother. These parts of the body answer through repetition the fearful question, "Do you love me?" In this early age, the ego is too weak to have sufficient security. It is continually on a try-out through repetitive movements. Later, compulsions are based on such preformed bodily patterns.

The movements and the change of the postural behavior seem to aim at the relief of tension. If the tension is fully and adequately discharged, no repetition should follow, but, if the psychologic stimulus is left undischarged, the postural constellation will be repeated. Therefore, the repetition follows as long as this substitutional discharge is incomplete or inadequate.

From methodologically studied postural behavior patterns, one is impressed time and again with the rigidity of the postural configurations, which apparently represent a defense mechanism, expressed in a habit formation.

This habit formation is, then, the sum total and the combination of involuntary, situationally conditioned positions of the limbs, the head, and the trunk in their relation to each other. This configuration is unconsciously and psychodynamically motivated. The basic posture will always be resumed—disregarding organic or external factors—unless the psychologic situation changes. If this basic posture or postures in a given situation are once firmly established, they will not change, even after very long interruptions of analysis. At least, it was so observed in 30 cases with intervals of from 38 to 59 days, after which the same posture was resumed as had been taken in the last session before the interruption of analysis.

Summary

Every individual has a basic posture. Every posture is meaningful and consists of a combination of different well-determined postures of single parts. All postures of the different parts of the body are attuned to each other, and the change of one partial posture leads to a rearrangement of the total configuration. The movement from one posture to another and the following position of the different limbs to each other is preconditioned by the representation of these parts in the unconscious. The configurations of the posture are bound to be characteristic for the person in question and depend on the firmness of the synthesization of the postural pattern within the personality. Drives and defenses once entrenched firmly in the basic posture lead to a postural defense line, which can be pierced only to a certain degree.

The repetition compulsion is an essential factor in the establishment of the basic posture. During the free associative procedure, unconsciously determined involuntary movements break through. This breakthrough depends on the degree of regression at a certain moment and on the kind of symbolization of the part of the body in question, or on the sort of inhibitory and defensive factors involved.

The posture changes whenever a shift in the psychodynamic situation takes place for which another postural expression is needed. The postural behavior substitutes and may precede the verbalization of the unconscious material. Emerging postures seem to be the product of a long developmental process and have their roots in the earliest childhood. Some betray their early origin by their similarity with infantile postures.

The change of postures seem to aim at the relief of tension. If the psychologic stimulus is insufficiently discharged, the postural configuration will continue or will be repeated. Observations of hand and finger postures show how minutely the postural pattern is laid down. The tenacity of basic postures is clearly proven by their repetition even after a long interruption of analysis.

DIVISION OF MYCOLOGY

PLANT-TISSSUE CULTURE TECHNIQUE FROM THE MYCOLOGICAL VIEWPOINT*

By MICHAEL LEVINE†

The study of the growth and development *in vitro* of tissues of the higher plants is of recent origin. Though conceived by Haberlandt in 1902, it did not attain a measure of success until the second decade of the present century. Excised roots of the pea and corn plants were first grown in a solution of mineral salts, to which were added organic chemicals and extracts of beef or yeast. The growth of these organs was limited however, and it was not until an attempt was made to subculture these growths that the prolongation of life of these cultures was attained. These cultures were not of a progressive type; they gradually dwindled in size and then failed.

The study of plant tissues or organs *in vitro* remained inactive until after 1930, when this activity became centered around the work of Gautheret and Nobécourt in France and White in America. Gautheret shifted the interest from the growth of organs to the meristematic tissue, the cambium of various trees like the willow, the elm, and others. He succeeded in growing pieces of excised cambium tissue under sterile conditions for considerable lengths of time. Nobécourt succeeded in growing meristematic tissue of various roots and began early to study the needs of the tissues that would insure their growth. White's study led to the first prolonged cultivation of excised fibrous roots. He compounded a synthetic nutrient solution which is widely used and which forms the basis for plant-tissue culture studies. In 1939, he claimed the prolonged growth and development of cultures of undifferentiated tissue.

The relatively short period, 1934 to 1939, witnessed rapid progress in the study of growth, *in vitro*, of plant tissues. Suitable nutrient solutions were improved, the physical conditions of the cultures were investigated, and the technique in the preparations of the primary cultures became more stabilized.

From 1939 to the present, the study of plant tissues took on a new phase. In America, pathological tissues, such as those derived from the callus of the tobacco hybrid (*Nicotiana glauca* x *N. Langsdorffii*) and the tumors of the crown-gall disease of the sunflower, were studied principally. The calluses of the tobacco hybrid are spontaneous globular growths with leafy elements which appear on the root, stem, and pedicels of the maturing plant. Contaminants are present, but they are limited to the surface of this overgrowth. The crown-gall tissue, studied mainly by White, Braun, Riker, and DeRopp, represents a sporadic secondary tumor on the sunflower which is free of the tumor-inciting bacteria.

The crown-gall disease is induced by piercing a chosen part of a plant with a needle that has been immersed in a subculture of *Phytomonas tumefaciens*. Tumorous growths appear in the region of inoculation. The bacteria, though not seen in microscopic sections of the tumor, grow rapidly on the agar medium when fragments are appropriately seeded. The bacteria-free crown-gall tissue has been used extensively for physiological studies by Riker and his students and DeRopp.

In this laboratory, the so-called "non-pathological," frequently referred to as the "healthy," tissue and the pathological type have been the subjects of our endeavor. These tissues were cultivated *in vitro* so that their growth was attained to the exclusion of bacteria and other mycotic organisms. Segments of stems and of fleshy roots, together with small plugs of tissue (2 mm x 3 mm) from the meristem of roots of a long list of plants, were seeded on nutrient agar. The technique employed has

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yielded tissue cultures of the carrot, tobacco, sunflower, Jerusalem artichoke, parsnip, salsify, and kohlrabi. Many plants yielded poorly to *in vitro* growth, principally because their contaminants thrived on the medium better than the host tissues.

The techniques employed in the preparation and study of plant-tissue cultures, as elaborated by White, require extensive facilities, such as air-conditioned chambers for storage of cultures, medium room, transfer room, and laboratory for preparation of nutrients. On the other hand, the European methods are simple and inexpensive. The open laboratory, with sterile instruments and paper, a gas flame, and a beaker of alcohol constitute the chief accessories to the successful induction and transfer of tissue growths.

Subcultures are made in a small glass wall-chamber, the size of which permits the free use of both forearms and room for as many as six to eight 125 ml. flasks at one time. Sterilization of instruments is accomplished by water kept at boiling point by an immersion heater. The hands are repeatedly washed and rinsed in alcohol. Erlenmeyer flasks, with medium and tissue cultures, are kept on racks in the laboratory. These are covered with sheets of cellophane so that the shelves are completely enclosed.

The organs of the higher plants have been considered "healthy." Since 1936, the notion prevails that these plants, though healthy in appearance, not only have ever-present surface contaminants, but also harbor many types of microorganisms in their internal tissues. The most recent study (Tervet and Hollis) shows that plugs of tissue of the common underground stems and roots like the potato, carrot, turnip, *etc.* yield bacteria when placed in sterile water. Precautions have been taken to sterilize the surface of the organs. Clostridial forms and Gram-negative rods are common. In our studies, entire sets of experiments were frequently discarded owing to contaminants residing in the primary inocula. These bacteria seem to grow better, even on White's medium, which elicits slow growth-reactions from the seeded tissue. Frequent transfer, with the hope of eliminating the invaders, rarely proves effective. The use of such material invariably results in loss of time and medium.

The carrot taproot and other structures used to initiate and develop tissue cultures were carefully selected. Taproots were bought in the open market and planted in beds in the green house. When leaves had developed, they were removed, washed in running water over night, scrubbed, and surface sterilized by immersion in chlorox or rose-x in proportions of 1:4 for one hour. They were then washed in running water again, rinsed abundantly in distilled water, and finally rinsed in alcohol. The root was brought to the transfer chamber and broken into two, and, with the aid of sterile cork-borers or trocar, appropriate lengths of tissue of a given diameter were removed from the generative zone and placed between sterile sheets of paper in the chamber. The tissue was then cut into desired lengths. As many as six inocula were then placed on the surface of 25 ml. of a sterile medium in chemically- and heat-sterilized 125 ml. flasks.

Stems of tobacco (*N. tabacum*, *N. affinis*, *N. Langsdorffii*) and the hybrid tobacco, sunflower, and Jerusalem artichoke stem, were all grown in the green house. After their removal from the plant, they were treated as just outlined. To insure removal of surface contaminant, the outer epidermis was removed under the protection of the transfer chamber. The stems were then cut into segments several mm. thick and seeded. Many of these segments yielded bacterial contaminants.

Crown gall induced by *P. tumefaciens* on the stems of sunflower, *Bryophyllum*, and kohlrabi and roots of salsify, parsnip, and carrot yielded no actively growing tissue cultures after treatment with the antibacterial products such as penicillin, streptomycin, aureomycin, and tyrothrycin. Surface sterilization of sunflower and *Bryophyllum* crown galls by sodium hypochlorite has

yielded slow-growing tissues free of the tumor-inciting bacteria.

The cell of healthy plugs of root and segments of stems begin to proliferate. They overgrow the surface of the inoculum and spread to the medium. This tissue is removed from the original inoculum after several months and transferred to fresh medium, where growth proceeds until sufficient tissue is formed to make a number of subcultures.

These new cultures represent fundamental tissue growths. It is this type of growth that has been studied in this laboratory. In the process of dividing, transferring, and final storage of this tissue, contaminations by molds, yeast, and bacteria occur. The loss in number is small, but the time lost may be exceedingly great.

Cultures of tissue derived from the carrot taproot and grown *in vitro* have been intensively studied by Gautheret and Nobécourt for more than a decade. They pointed out independently the need this tissue has for the plant growth substance, indoleacetic acid (heteroauxin). This substance, added to the mineral salts, sucrose thiamine, and oligodynamic elements, enables the carrot tissue to grow.

In 1946, fragments of carrot tissues were started on a mineral-salts-and-sucrose substrate, and the tissue masses derived were primarily used to study the effect of the chemical carcinogens. Three such chemicals were used: 1,2,5,6-dibenzanthracene; 3,4-benzypyrene; and 20-methylcholanthrene. The new tissue growths were so divided as to form five cultures: one was grown on a standard medium; another incorporated in the same medium, indoleacetic acid at a concentration of (5×10^{-6}) 0.5 mg. per cent; and the other three each contained, besides the standard medium, a definite concentration of one of the carcinogens.

Tissues grown for several transplant generations on heteroauxin and then transferred to standard nutrient or medium, in which dibenzanthracene had been incorporated, began to show evidence of shoot formation with roots. This occurred eight months after the primary cultures were started. Within a period of a year, the cultures produced complete carrot plantlets. Besides showing morphological and physiological differentiation, these tissue masses, following growth on heteroauxin, presented characteristic changes common to the crown-fall disease. Similar responses were elicited by the chemical carcinogens. Growth of the tissue appeared to be stimulated.

Cytological studies of the plantlets revealed tissue structures not unlike those induced in plants by the crown-gall organism. It is believed that the response is not one of crown gall but that of a protective mechanism exhibited by the plant regardless of the source of injury, whether a parasite or a chemical agent. Segments of the tobacco *N. Langsdorffii* and *N. affinis* produced tissue masses which yielded complete plantlets.

In subsequent studies, which are to be reported elsewhere, fibrous roots derived from pedigreed cultures and whole segments of carrot roots have been observed to form tissue masses from which completely differentiated carrot plantlets were formed.

Summary

(1) Meristematic or generative tissue of higher plants may be grown on pure synthetic medium to form tissue cultures with unlimited capacity to proliferate.

(2) Tissues of healthy higher plants show bacteria gain access to the tissue most likely through small wounds or lenticels.

(3) Careful selections of organs, surface sterility, removal of surface epidermis, and use of the inner tissue reduce contamination most frequently caused by bacteria.

(4) Division and transfer of the tissue culture expose it to contamination by molds, of which *Penicillium sp.* is most common.

(5) Tissue cultures of the carrot taproot and segments of tobacco stems (*N. Langsdorffii* and *N. affinis*) yielded completely differentiated plantlets.

(6) Cytological studies of the tissue masses and some plantlets of the carrot

examined consist of tissues not unlike crown gall after growth on the chemical carcinogens.

References

WHITE, P. R. 1943. A Handbook of Plant Tissue Culture. xiii: 277. Jacques Cattell Press. Lancaster.

GAUTHERET, R. J. 1942. Manuel Technique de Culture des Tissus Végétaux: 172. Masson et Cie. Paris.

GAUTHERET, R. J. 1945. La Culture des Tissus: 202. Gallimard.

NOBÉCOURT, P. 1943. La Culture des Tissus et des Organes Végétaux. Rev. Sci. **81:** 161–170.

HILDEBRANDT, A. C., A. J. RIKER, & B. M. DUGGAR. 1946. Am. J. Bot. **33:** 591–597.

TERVET, I. W. & J. P. HOLLIS. 1948. Phytopathology **38:** 960–966.

SECTION OF ANTHROPOLOGY

LIFE IN THE EARLY ISLAMIC CITY OF NISHAPUR, PERSIA*

By CHARLES K. WILKINSON†

The acquisition of objects of value by digging for them on ancient sites has a long but not particularly honorable past. Looting and learning have often gone hand in hand, with sometimes the one and sometimes the other taking the lead. Eventually, archaeological digging was done with the express intention of corroborating history as it was known from literary sources, such as the Odyssey and the Bible, and much work was done to that end at Troy and in Assyria, Egypt, and Palestine. Nowadays, some of our knowledge of early man in the remote past is being gained almost entirely from archaeological excavations. We must remember, however, that the archaeologist is always in danger of basing too much on too little. Even museum curators have been naïve enough to believe that digging surely will give them definite answers to embarrassing questions of date and provenience. It seems that archaeology, from being an acquisitive child (and, like all children, none too careful of how and where it gets things), has come to be considered an oracle.

To have some understanding of the past without losing oneself in it is a reasonable and profitable intellectual pursuit, though we know that each age can only see the past in its own peculiar and limited way. It is well, however, to look at that past as honestly and completely as possible and to avoid Oliver Goldsmith's indictment, "But of all the learned, those who pretend to investigate remote antiquity have least to plead in their own defence when they carry this passion to a faulty excess. They are generally found to supply by conjecture the want of record, and then by perseverance are wrought up into a confidence of the truth of opinions which even to themselves at first appeared founded only in imagination."

The part that archaeological excavation can play in this examination of the past is distinctly limited, and, if any clear understanding is wanted, it is necessary to supplement that work by information from other sources and by other means. Literature, the visual arts of representation, ethnography, and anthropology all can be of assistance to this end, but each of these will prove incomplete and unsatisfying if pursued solely along its own lines.

In literature, some things are never written; in painting, some things are never depicted; and Time sees to it that, no matter how carefully an ancient site is excavated, only a certain amount of the original material remains. The result is that, willy nilly, false emphasis is placed on that which is preserved. The objects found may be and often are in puzzling disorder. The living people in the locality may and

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frequently do reflect much of those who lived before them, but it is often exceedingly difficult to judge just how the old and new habits and customs are intertwined.

The purpose of this paper is to describe some aspects of the early Islamic city of Nishapur and those who dwelt within it. To this end, I have combined information gathered from sources ancient and modern, from the literature of the past, from observation of present-day life, and from the excavations made by the Metropolitan Museum.

The reports written of Nishapur in early Islamic times contain much contradictory material. This need hardly be a matter of surprise, for there is no reason to think that those who visited foreign parts and strange places in ancient times were any more exact in their reports or less affected by their emotions and personal peculiarities than they are today. It was just as possible then as it is now to damn a city or a whole country because of an unfortunate encounter with a tough and unsympathetic official. The following quotation from the poet Muradi is, I am sure, an example of this: "Be careful not to go to Nishapur if you are not closely protected by the sultan, for in this city neither merit nor high birth is a safeguard, and the respects due to a man are not recognized." The early literary records run the whole gamut from praise to blame. Anwari, a famous poet of the late twelfth century said: "How excellent is the city of Nishapur which is upon the face of the earth: if there be a Paradise it is here, and if it be not this then it does not exist." Another man, most extravagant in his praise of Nishapur, gives himself away when he says, "and there I found the most beautiful creation of Allah—in the form of a Turkish slave." At the other extreme we have a learned man who, alas, as some learned men do, got a little sour: "For six years," said he, "science and culture have kept me imprisoned in the dust heap of Nishapur." As this man goes on to say "I have so excelled in all the accomplishments that anyone has mentioned, that in all the world I have no second," we can consider his powers of judgement distinctly warped. Some writers show a better sense of proportion. Of Rayy, once a great Persian city near Teheran and on the main road to Nishapur, Ibn Haukal wrote in the tenth century, "except for Baghdad it is indeed the finest city of the whole East though Nishapur in Khurasan is more spacious."

At present, Nishapur is a small town about ninety miles southwest of Mashhad on the main road that goes from Teheran to Afghanistan. This road is one of the great highways of Asia and has been called the "Khurasan road" and the "great silk road." Khurasan is now the northwest province of Iran, but in earlier Muslim times the name, which means the land of the Rising Sun, was applied to a much vaster area, which included both Bokhara and Merv. The name was sometimes used to designate the land right up to the Oxus river. Nishapur was, on occasion, the capital city of this vast area, though other cities, such as those I have mentioned, were effective and usually successful rivals.

Nowadays, Nishapur is mostly a by-stop that caters to the pilgrim tide that flows to the shrine of the Imam Riza, the eighth imam, at Mashhad. The Imam Riza, much revered in Persia, died in the beginning of the ninth century, supposedly poisoned by the Caliph Mamūn, son of Haroun er Rashid. Both the Imam Riza and Haroun er Rashid are buried in Mashhad, the Imam Riza in a silver shrine, which is almost worshiped, while that of Haroun er Rashid is neglected, if not actually desecrated. Each, however, has become more or less immortal, the one through the religious faith of Shi'ite Muslims and the other through the fabulous but highly informative fables known to us all as "The Thousand and One Nights."

Nishapur existed as a city before either of these men lived. Its very name betrays its Sasanian origin, for Shapur was the name of several Sasanian kings. We are not now concerned with the Sasanian city,

however, and no traces of it were found in the excavation conducted by the Metropolitan Museum. There is every reason to believe that the Sasanian city continued to be used for at least a whole century after its capture by the Arabs. Then a new city was developed in a suburb, usually referred to as Shadyiakh, some miles away. Exactly this sort of thing happened at Shiraz, where the museum also worked, except that there it was the Sasanian fortress and adajacent town that were excavated. Cities in Persia were often rebuilt several miles away from their original sites, and suburbs can be considered to mean villages within thirty miles in the same plain. In Nishapur, no buildings found by the museum could be definitely dated before the beginning of the ninth century, though some may have been erected in the late eighth century. Much was probably built by 'Abdallah ibn Ṭahir and by 'Amr ibn Lais who wished, according to report, to conquer a place where the grass was rhubarb, the earth was covered with vegetation, and the stones were turquoises. These qualifications may seem utterly fantastic to anyone unacquainted with Nishapur; yet Nishapur is still famous for its rhubarb and the syrup which is made from it. The plain is still exceedingly fertile and the turquoises found in the mines a few miles away are still the finest obtainable.

The city that flourished in the early days of Islam now lies beneath a vast area of land, which is cultivated even though it is thick with fragments of ancient brick and pottery. The flatness of the plain is broken here and there by the ruins of walls and by hillocks formed of the old buildings—the sun-dried bricks have again become the earth from which they were made. Dominating the site is a great mound, known as Teppeh Alp Arslan, named after the famous Saljuk Turkish conqueror of the eleventh century.

This huge mound was erected in the ninth century and formed the platform on which the citadel was built. It is not a mound composed of the accumulated detritus of many ages. This practice of making raised earthen platforms was not confined to Nishapur; the citadels at Bokhara and Samarkand are raised above the plain in the same fashion. The top of the mound was covered with small dwelling places, following the pattern set by the Sasanian fortresses, such as that as Kasr-i-Abu Nasr at Shiraz. The fortress was used until the thirteenth century, when, after the Mongols sacked the town, it appears to have been abondoned. The citadel and the town were enclosed by walls made of trodden, puddled earth. At the citadel, there is some evidence of its having been reinforced with stones.

The walls were pierced by two and four gates respectively, that on the East being called ominously the War Gate. Wars were frequent, and the city changed hands repeatedly between the ninth and the thirteenth centuries. Several of these affairs were exceedingly bloody and we read of slaughter even in the great mosque itself, with the floor covered with bodies and invisible from the blood in which they lay. Persians, Arabs, Turks, and Mongols all used the sword ruthlessly in this city. The chief blame seems to rest on the Mongols, who built separate pyramids of the heads of men, women, and children. In any case, the resurrections of the city were extraordinary despite wars, massacres, and terrible earthquakes. In 1267, Pur-i-Baha describes broken minarets, libraries upside down and colleges all forsaken, the Friday mosque in ruins and the pulpits shattered. In 1270, he speaks of old Nishapur being young again, like a dotard regaining his boyhood. This reference alone shows that even before the earthquake of 1280 the city had recovered to no small extent from the Mongol invasion.

There undoubtedly were caravanserais near the gates in ancient times. Long strings of camels came there, rested, and went. Places for the same use still exist, for the traffic of motor trucks has by no means entirely displaced the heavy and powerful camels of the region. The old

khans, too, that opened off the narrow streets of the bazaar, were probably not much different from those of today. The ancient bazaar was built in the form of a cross and, as is usual in the Near East, was divided into sections, according to the nature of the goods sold and made there. Nishapur was especially famous for its silk and cotton weaving. There were, however, many other things locally made and, in addition, many imported goods from China in the east and from Iraq, if not from even further to the west.

Near the encircling walls and by some of the largest buildings were great depressions in the ground from which clay had been taken for making bricks. We found such depressions in our excavations. In early Islamic times, most bricks were sun-dried and the buildings, when complete, were usually covered with a coating of mud and chopped straw, which in some instances was covered with a thin coat of white plaster. Generally, the city must have been of a dun color, with some of the larger and more important buildings glistening white. It is probable that, on certain occasions, some buildings were just white-washed before the arrival of important persons, as is often the case in the country in the present century.

Kiln-fired bricks were also used, the kilns being near the walls or even outside them. The fire burned the clay a bright yellow, as is the case at the present time. There were exceptions to this, however, and in the Saljuk period, *i.e.*, the eleventh and twelfth centuries, elaborately carved bricks were fired to a dull red color. These special bricks were of huge size and were carved with inscriptions and ornament. They were used as decorative bands on the surfaces of some of the mosques and other such buildings. Our excavations revealed a detail that had not previously been known. The background of such cut and carved bricks was colored bright blue or a vivid red from a pigment containing cinnabar. It is probable that the decorated surface was painted white. Also introduced in Saljuk times was another form of brick and tile decoration in which the brick, instead of being made of a natural clay, was made of a composed body and was covered with a bright blue alkaline glaze. There were two intermediate techniques—though they were all contemporary. In one, the tops of the letters were glazed blue and the background and other decoration were painted red; in the other, scraps of flat blue glaze were fitted into holes cut in the bricks. This introduction of the glazed brick and tile was a resurrection of an art the Persians had learned from the Babylonians and which they practiced during the Achaemenian period. This was an art of the so-called "barbarians" which was killed by the Greeks. Evidently the Greeks could kill arts as well as sow them.

There were many mosques in the city. One of the most important was built by Amr ibn al Laith toward the end of the ninth century. We have a fairly full description ot it, but it cannot be verified, as the remains have yet to be discovered. It appears to have had three arcades around a great court and eleven gates flanked by marble columns. The chances are fairly good that the piers of the arcade were like those of the mosque of Ibn Tulun in Cairo, which was related in style to the famous mosque at Samaria in Iraq, a ninth-century building. I think this is likely, for some piers of the same type, and certainly of the ninth century, were uncovered in our excavations. Some of the mosques were of considerable size. We read, for example, that the mosque of Mutarriz, which was sacked by the Ghuzz Turks, held 2000 persons. On the other hand, other places of worship were exceedingly small. A feature of Nishapur was the introduction of shallow plaster prayer niches into the rooms of small dwelling places.

Some of the most important buildings in Nishapur were the religious colleges, known as *madrasehs*. The word unfortunately has become associated with a particular type of building in which four

vaulted recesses form the sides of a rectangular open court. There is no evidence that this kind of *madraseh* was ever built in Nishapur. There were many *madrasehs* in the city and one of the first great Saljuk *madrasehs* was built there. At this time, the Sunni form of Islam was the official one, and the special form taught in the *madrasehs* of Nishapur was the Shafí doctrine. Religion and politics as well as religion and law were most closely allied. The Nizam el Mulk was the great statesman or wazir of the eleventh century. He endeavored, by means of the *madrasehs*, or colleges, to achieve some cohesion in the vast state under Saljuk rule and to combat the propaganda of the Shiá sect and other dissidents who were active in the *khanegahs*, or cloisters. We have records of quite a number of the doctors and jurisprudents of Nishapur who taught in these colleges, of which, according to Nasr-i-Khusrau, there were no fewer than seventeen in Nishapur alone. The most famous of these teachers, and the one whose influence has probably lasted longest, is Ghazzali, whose writings are supposed to have influenced Thomas Aquinas. His works are still read and his ideas are still actively discussed both in Persia and elsewhere.

There are many literary references to scholarship in Nishapur. One of the earliest concerns 'Abdallah ibn Tahir, the great governor of the early ninth century, who, though he ordered the destruction of an illuminated Magian book, is quoted as saying, "Knowledge must be accessible to the worthy and the unworthy: knowledge will look after itself and not remain with the unworthy."

About the end of the tenth century a book was written by a Nishapur scholar named Jauhari entitled *Tarikh-i-Ulema-Nishabour* —which was a history of the doctors of Nishapur, but the work unfortunately has disappeared, though it was used by later writers, more particularly by Ibn Khallikan in his biographical dictionary written about 1250 A.D. From this latter book and from the *Tarikh-i-alfī*, the Millennial History, written in 1588, we get some sidelights on the learned men of Nishapur and amongst them an incident in which Omar Khayyam, the great mathematician, and poet, plays the leading role. Omar Khayyam was supposed to believe in the doctrine of metempsychosis. One day when an old college was being repaired, he was walking by with a group of students and saw that one of the donkeys bringing bricks would on no account enter the *madraseh*. Omar Khayyam smiled, went up to the donkey and recited extemporaneously the following quatrain:

"Oh lost and now returned yet more astray,
Thy name from men's remembrance passed away,
Thy nails have now combined to form thy hoofs,
Thy tail's a beard turned round the other way."

The donkey then entered and the students asked why his verse had such a magical effect. Omar Khayyam smiled and said, "The spirit which has now attached itself to the body of this ass formerly inhabited the body of a lecturer in this college, therefore it would not come in until now when, perceiving that its colleagues recognized it, it was obliged to step inside."

From the ninth to the twelfth centuries there was much disputation on religious matters, but the strife, though sometimes vehement and deadly, was not more bloody than in Christendom, perhaps even less so. Nishapur was no exception and was a hotbed for various sects. There were several tendencies at work. The Muslims who believed the Koran was created found it not incompatible with Greek philosophy. They were gradually taking second place to those Muslims who took the Koran literally and who, considering it divine, were logically driven to maintain it existed before it was written. There were many 'Alids and they formed the Shiá or faction, that division of Islam which believes that the Caliphate should have remained in the family of Muhammed. It is to this faction that the great majority of Persians now belong, but during almost the whole of the early period of Nishapur's history it was

to the orthodox or Sunni sect that its rulers belonged.

Another religious force strong in Persia and Nishapur was Sufism, which gave a mystical turn to Islam. The Sufis believed not only that there is no God but God, but that there is nothing but God. Al Hallaj, who was born in Khurasan, speaking of God said, "Betwixt me and Thee there lingers an 'It is I' that torments me. Ah, of Thy Grace, take away this I from between us." It was indeed taken away from him, for, by maintaining that he was the Truth (which was considered tantamount to saying that he was God), his fate was sealed and he was beheaded. Some of the greatest minds were influenced by the Sufis, one of the most important of those who taught at Nishapur being Ghazzali. He, however, did not go to such lengths as Al Hallaj. One reference to a book known as the *Mishkat al Anwar*—the niche for lights—written by Al Ghazzali will give an indication of the hair splitting and logic chopping that went on in Nishapur and other centers of learning. He quotes a couplet from Al Hallaj which runs:

"I am He whom I love and He whom I love is I.
We are two spirits immanent in one body."

He treats this critically and then gives another verse:

"The glass is thin, the wine is clear,
The twain are alike. The matter is perplexed;
For 'tis as though there were wine and no wine glass there,
Or as though there were wine glass and nought of wine."

He then points out that there is a difference between saying, "The wine is the wine glass" and "it is as though it were the wine glass," and he indicates that a man unconscious of his own consciousness is in a state called in the language of metaphor, identity, and in the language of reality, unification.

In many of these religious matters, however, political interests were often involved, and it is not easy to assess how much the theological strife of the day affected the learned circles of the city. For the general population, it probably made little difference. The one thing that seems certain is that most of the time there was room for a considerable difference of opinion between the various sects of Islam. Some of their various adherents could, when things got too hot, avail themselves of the art of dissembling their true beliefs without falling from grace, while outwardly conforming with that which was publicly professed. Even between the adherents of different religions enmity was not too great, for Abu Muslim, the great and unscrupulous champion of the Abbasids, nevertheless was a friend of Sinbad of Nishapur, a Zoroastrian, who, after Abu Muslim's death, attempted a revolution with fatal results, his death being due to his political activities.

Although there were so many mosques, *madrasehs*, and convents in Nishapur, we were reminded by several finds in the excavations that there were other religious faiths in the early city. Several objects were found which were decorated with crosses, as for example, plaques and glazed pottery. It was quite obvious that the crosses on these things were used as a Christian symbol and not as a haphazard decorative device. Records have come down to tell us that there were enough Christians of the Nestorian faith in Nishapur to have their own bishop.

During the ninth and tenth centuries there were still many Zoroastrians, for not until the eighth century was there any major adoption of Islam.

Mani lived in the third century after Christ and founded a dualistic religion. His followers, the Manichaeans, spread his faith in Europe and Asia and were persecuted in Christendom and Islam. Some of them, too, were probably in Nishapur, with their numbers being temporarily increased during the tenth century, when they were driven out of Mesopotamia and obtained temporary refuge in Khurasan before proceeding further East to Turkistan, where remains of their paintings have been

preserved. They were famous for their proficiency in the art of painting and it is most probable that their influence was felt in Nishapur. Be that as it may, we have material evidence that wall painting was practiced in the beginning of the ninth century. Unfortunately, there were but few remains showing human figures. These were discovered all broken up at the bottom of a pit near a house. The large figures had haloes and there were demons included in the scene, but not enough was found to give the key to the subject.

In one figure, the head of a woman, two peculiarities may be noted: (1) the very small size of the mouth, which fulfills the mark of beauty as favored in Persian poetry—"a mouth smaller than an eye" (the English equivalent is a "rosebud" mouth); and (2) the two black spots beneath the eyes. These last are not tears, but are either tattoo marks or, more probably artificially induced scars. The practice in Iran seems to have gone back to Parthian times, and perhaps to long before that. As Dr. Schuster points out, however, the custom has persisted among the Mongols. To my mind, this curious custom is perhaps related to the prevalence of the *salaq*, the circular scar left by a boil that often breaks out on the cheek, to which the inhabitants of the Near East and Turkistan are very susceptible. It is not inconceivable that a blemish was changed from a stigma to an artificial beauty spot by reproducing it on the other cheek in much the same way as has been done in the west with moles and patches. In any case, this strange fashion is in no way peculiar to Nishapur; it was and is widespread.

Other paintings found in their original positions on the wall contain no human figures but, in addition to elements that are purely decorative, there are others which obviously once conveyed some special meaning. On one panel, for instance, can be seen pairs of groping hands, each with a circular device on the palm. In another, the hands stretch out to small pyramids of fruit or to a black disc. These features are not to be found in any of the ninth-century paintings that have been found so far, in Iraq or elsewhere. In small elements from the painted plaster filling of a squinch of the ninth century, two prominent eyes appear. The use of this motif is very widespread both in time and place. It is still one of the peculiarities of small Mediterranean ships. In early Nishapur, it occurs not only in wall paintings but on a number of small metal objects, and we are reminded that the Scythians and other nomad tribes near this area used this symbol frequently. Their use can be associated with no one religion but would seem rather to be evidence of some superstition common to large groups of men. In Nishapur, not only was the eye itself depicted in this particular way, but charms were worn to defend the wearer against the evil eye. In early Saljuk times, it was possible to make very cheaply bright blue glazed pottery amulets which resembled turquoise, the efficacy of which against the evil eye has been held paramount for centuries. As defense against the same threat, charms were also written from the Koran and, in the case of the well-to-do, placed in cylindrical containers such as one of silver gilt, with an inscription in niello work, which has been preserved from the early ninth century. It was made to be suspended from a cord encircling the neck. In this instance, the inscription is a particularly potent one, for it is the chapter of unity and its recitation was equal in merit to the reading of a third of the whole Koran.

Another indication of unorthodox beliefs or myths was found in the form of some broken molds made of well-levigated clay. The subject of a bird (here perhaps human-headed) flying upwards, with a human figure against its body, is, of course well known, but it goes back to long before Greek times, as far back indeed as about 3000 B. C. in ancient Sumaria. The subject crops up again and again. It figures in the Shahnameh in the story of the albino hero named Zal.

Concerning more material things, a

matter of the utmost importance in the relatively dry region of Khurasan was the procurement of water. Several early writers have remarks to make about the water supply of Nishapur. They note, for example, that it was rather far below the surface of the earth and, according to at least one report, one could descend as many as 100 steps to reach it. The longest flight of stairs to a source of water that was revealed by the excavations was 33 steps and the 100 can probably be taken for an exaggeration. Water channels did pass deep beneath the surface of the city, and one dissatisfied visitor suggested that Nishapur would have been a much nicer place if the water had been on the surface and the inhabitants down below.

The water was brought from the near-by mountains by means of underground aqueducts in the form of small tunnels lined with pottery hoops shaped much like horse collars. These hoops are still being made, in kilns on the outskirts of the modern town. The water eventually came out at surface level south of the city and was used to irrigate the land. This means of conducting water has a long history in Iran and goes back to at least the first century. Its distribution was always a most fruitful source of trouble. Recognizing this, 'Abdallah ibn Tahir, who built part of Nishapur in the early ninth century, had the "Book of Canals" written. It served as a guide for the legal distribution of water for at least two centuries. There are literary references to reservoirs of water at Nishapur, but, apart from a few small pools, their number would seem to have been in no way exceptional. It would seem rather that the main way of getting water was from subterranean chambers, through which the underground watercourse passed. The finest one was a domed octagonal structure built of kiln-fired brick, with seven recesses and entered by a steep flight of stairs. The water emerged from the tunnel and flowed into and from a tank into which women could dip their pitchers and men their goat skins. There were also innumerable wells, often in very close proximity to latrine pits. I believe that the minimum distance considered necessary to insure absence of pollution is at least 200 yards. In Nishapur, the distance was nearer 2 than 200. The wells were often, but not always, in open courts on which rooms of the house opened.

The houses themselves were usually built of sun-dried brick and, apart from the poorest hovels, were covered within by coats of fine white plaster, which were renewed when necessary. The floor also was covered with white plaster and, in order to keep it clean, there was often, in the more luxurious houses, a general raising of the floor except for a rectangular space adjoining the actual doorway. This area was sometimes provided with a small drain hole. Another feature that seems to be peculiar to ancient Nishapur was the intrusion of a sunken pot in the center of the floor. The orifice was usually surrounded by a small rectangular moulding. Charcoal was placed in the vessel and air was introduced at the bottom by means of an inclined pottery pipe. It might be wondered how such a small amount of fuel could possibly heat a whole room, and of course it could do no such thing. This central sunken charcoal fire was used as the Persians in the country still use a charcoal brazier. Over it is placed a wooden framework known as a *kursi*, and over this structure quilts are thrown. People then sit or lie around, with most of themselves beneath the covers. It is a most ingenious, simple, and economical way of keeping warm. But as a Persian once said to me, "It is very pleasant indeed to sit beneath a kursi, but one doesn't get much work done."

In connection with the sunken fireplace, the answer was found to a troublesome question which arose concerning a number of stone animals that had been found in the excavations. These animals had one feature in common—a deep notch in the middle of the back. A brazier of the late thirteenth century, now in the Metro-

politan Museum, shows special hooks at the sides for holding a spit when the brazier was used for grilling. A miniature in the Museum of Fine Arts at Boston shows a picnic in the open air, and one can see that little metal spikes of a similar shape had been put in the ground for this same purpose—a development of a simple forked twig. Such spikes were not driven in the plaster floor and the notched stone animals took their place, being placed on either side of the sunken fire to support the spit.

On the plaster floors, rugs were scattered, which, with their brightly colored wools, introduced some color into the white interiors of the houses. Just before the close of our work in Nishapur, in examining a large room of an important building, we discovered that the original plaster floor (for it was composed of many successive layers) had been painted brightly in red and blue, a feature not hitherto encountered. Unfortunately, it was so damaged that it is impossible for me to give any idea of the pattern with which it was adorned. It hardly seems a very practical idea; yet the evidence is incontrovertible.

The most gaily painted places were bath houses, both public and private, as far as we are able to tell. Considerable license has always been practiced in Muhammedan countries in the decoration of these places. They were replastered and repainted over and over again. One that we excavated had lively scenes, though unfortunately it was possible only to guess at most of them. Animals, birds, human figures, and winged angels were painted on the walls. There is no doubt whatever that the miniature paintings that have been preserved from the thirteenth- and fourteenth-century bestiaries, of which pages exist in the Morgan Library and the Metropolitan Museum of Art, followed this earlier tradition of painting in direct line.

The fact that people usually sat on rugs on the floor had its effect on the manner in which rooms were decorated. It was a perfectly natural and sensible thing to have the wall decoration, if there was any at all, in a band about a yard high, forming a dado. These dadoes were sometimes painted and they were composed of carved plaster. The decoration was cut directly in the plaster after it had been applied to the wall. The Persians were, and still are, very skillful at this work and succeeded in making most interesting patterns of light and dark, filling in regular geometrical shapes with varied but closely related ornament. The leafy forms are highly conventional, but they are treated with much ingenuity. Other elements, such as bird's heads, are often introduced, showing that the tradition of the north Persian art of Luristan and of the Scythians was anything but dead. The main borders of these plaster panels were usually painted a golden ochre, and the backgrounds of inscriptions, which were always in Arabic and never in Persian, were painted blue.

By means of plaster, the inhabitants of early Nishapur were able to have small glass windows. The glass has a yellowish tinge and is always undecorated when used for this purpose. The technique of setting glass in plaster in the Near East has survived until the present day, but, in western Europe, weather conditions did not allow it to be used and the practice of setting glass in lead calms took its place. The use of glass was widespread and many fine pieces have survived, although most of them are broken. Engraved plates and cut-glass bottles show great technical skill. The bottles and decanters were used for wine, which was made and drunk in Nishapur.

Although some glassware was probably imported, glass was made in Nishapur itself. Some of the glass of the ninth and tenth centuries was of very fine quality. Here is a verse of the tenth-century poet, Daqiqi, which illustrates the point:

Water and ice, behold within a glass
How candle-bright all three do shine, but see,
The twain will fuse, yet one a frozen mass
Remains. One hue, one luster have these three.

Some of the glass found in Nishapur really

was as colorless as ice. Glass was used for medical purposes, and we found traces of this at Nishapur in the form of several cupping glasses. They were operated by sucking the stalk-like tube that is annealed to the cup itself. Medical knowledge in the Muhammedan world at this time was far more advanced than it was in Europe, and Persia was well in the vanguard.

For domestic use, glazed pottery was far more common than glass, and most of it was made locally in domed kilns. Vessels of various shapes were made of it: cups, dishes, platters, bowls, and pitchers. Relatively few were plates, due to the fact that food was eaten with the right hand and knives and forks were not used. The hands, I should like to point out, were washed before and after eating in all decent circles, with rose water in the really elegant ones. Pottery was imported from both China and Iraq during the ninth and tenth centuries. In the tenth century, there seem to have been importations from other cities in Khurasan. The pottery from China must always have been rare and costly. From Iraq came the highly prized lusterware which the potters of Nishapur were never able to make, at least until the thirteenth century. That it was well thought of is proved, not only by the presence of the imported ware itself, but by the imitations made of it. As the technique for making these copies is entirely different from the original one, it is no wonder that the imitations bear only the most superficial resemblance to the true luster pieces and that the metallic iridescence is entirely lacking.

In underglaze painting, the potters of Nishapur produced some of their most effective achievements with an amazingly economical use of color and decoration. Using merely black and white, with an occasional touch or two of red, the results were, I think very satisfying and conform to our present-day taste.

From the Nishapurians' standpoint, a ware strongly influenced by Chinese glazed earthenware of the T'ang period was equally if not more popular. It has green and yellow splashes and often spots of purplish black on a white ground. More or less obliterated by these colors are scratched designs which are often of considerable delicacy.

Another style confined to Nishapur and to the north of Khurasan by the Caspian sea is remarkable for the extraordinary birds, beasts, and human beings that figure upon it. Apart from one other ware made in later times and the wall paintings, here alone do we have material evidence of the appearance of the people living in the city. From one bowl, we probably have some idea of how women dressed—presuming the figure to be a woman and not a young man. A curious cloak with divided tails seems to be peculiar to Khurasan, but this may be due to lack of information from other regions. On another bowl, leather leggings worn by a man may be taken as a definite part of the costume of a man of the upper classes. Also, he is drinking a glass of wine. Although in these drawings the beakers are usually shown with concave sides, those they actually used were tapering but with straight sides.

Fantastic though some of the bowl decoration may seem to be, it should not be cast out too quickly. Men did, for example, wear flowers in their hair, if accounts of certain convivial gatherings are correct. An animal sitting behind a horseman, strange and winged though he be, reminds us that hunting with cheetahs was practiced in Khurasan until the seventeenth century, the animal being trained to catch the prey and to sit behind his master's back on the horse's rump. A wall painting shows another method of hunting also still practiced in the near East and in Turkestan—hunting with a falcon. Most of the details of this ninth-century painting must be considered accurate, even the metal tags on the dangling ends of the man's leather belt. The woven roundels in a man's dress were worn throughout the Saljuk period in Persia and also in the corresponding period in Egypt. None of

the old garments were found in the ruins, save the metal tags just mentioned and ivory and bone buttons. These buttons were often extremely handsome and were cut and inlaid with color. There are no references to them in any writing, however, and no miniature shows how or where they were used. They have been found in hundreds of early Islamic sites from Egypt to east Persia, but only in Nishapur do we have any inkling as to how they were used. It appears that they were used in pairs—one large and one small, being joined by an iron haft. So far as I know, it is not a feature of any near Eastern dress, Arab or Persian, at this time. It is possible that the buttons were used in other ways also. Thus, we are almost as far away from the solution of the problems as we were before.

I mentioned previously another type of pottery which was introduced at a later date, the eleventh century to be precise. The introduction of this ware was a revolution from a technical point of view. The body was now composed of kaolin, flint in the form of sand, and feldspar, used instead of natural clay, and the glaze was chemically different from what it was before. It was now an alkaline glaze, instead of one that had a preponderent quantity of lead in the ingredients. The result of this change in the composition of the glaze was quite startling, for, from the copper oxide which had regularly been employed to get a brilliant green, the potters now got a brilliant blue, a color entirely absent in the earlier wares. Vessels of all kinds and amulets of this new color were made in great quantity. This major change passed entirely unnoticed in early literature and, from a casual examination of the pottery, could have easily been considered a passing whim of fashion. A technical examination showed very clearly, however, that the change was not one of mere chance. Desire and achievement are often far apart, but technique and fashion, like the words themselves, are more closely related than most people remember them to be.

One mold used in the making of this ware presents a rather charming scene of some musicians. It is of the Saljuk period of the eleventh or twelfth century. We had already found some actual bone pipes in a tenth-century house, but the pipes represented in the mold are of a different nature, much closer to the *zammara*, which is now played in Egypt. It is much like a clarinet in shape but has no keys. One of the instruments depicted here is a lute. (The word is a corruption of the arabic *el 'Ood.*) Music in early Muslim times was not just a repetition of traditional folk songs. There was a great deal of work being done on the theory of music and there were also many changes being made in the actual instruments themselves—particularly the lute.

At the risk of emphasizing a matter which may seem to be of little importance, I shall draw attention to another pastime, chess, practiced in Nishapur from the very beginning of the Islamic era. A number of ninth-century ivory chessmen were found in our excavations, as early as any set of pieces known. The invention of the game was credited by the Persians in the *Shahnameh* to the Hindus in the reign of Anurshirwan the Just, who reigned in the sixth century A.D. Through Persia, the game was introduced into Europe by the Arabs, though it was not widespread there until the eleventh century. In Spain a number of fine crystal pieces were preserved in various monasteries, and a cut-crystal set now in the collection of the Comtesse de Behagues shows a very close relationship to the pieces we found in Nishapur. In the manuscripts of Alfonso the Wise, written near the end of the thirteenth century, are a number of chess problems which have accompanying pictures. One is of two Arabs playing and another shows an Arab playing a Spaniard. In Nishapur, too, men of different races must have played many a game together.

I have been able only to give a glimpse or two of the way of life in early Nishapur, of its houses and the people who lived within, of their beliefs, their crafts, and

their pastimes. Our excavations have not always borne out that which was written by the early writers, and occasionally only a study of modern manners and customs has enabled us to understand some of the things that we have found. We have also learned something of matters never written of at all. In an endeavor to explain a major change in fashion, we were indebted to simple chemical analyses and found out why this change took place. I have undoubtedly dealt with minor problems and touched on the things that have interested me personally, often matters of no importance whatever; yet perhaps I have also shown that some of the elements of life in that city and some of the niceties of their way of life can be resurrected and can prove to be not so strangely different from our own as we might have suspected. Much of our learning, whether we are conscious of it or not, has been derived from the same sources as these early people of Nishapur. Further, they themselves have added, to no small extent, to our own sum of knowledge.

NEW MEMBERS

Elected November 17, 1949

LIFE MEMBERSHIP

Clarke, Donald, A., A.M., Pharmacology. Research Fellow, Cornell University Medical College, New York, N. Y.

Johnson, Selina (Mrs. Herbert H.), B.A., Photography. Free-lance Photographer, Leonia, N. J.

SUSTAINING MEMBERSHIP

Lloyd, Jerry, A.B., Medicine. Real Estate Salesman, L. J. Phillips & Co., Inc., New York, N. Y.

Sands, George W., M.D., Circulation. Research Fellow, Goldwater Memorial Hospital, New York, N. Y.

Steinman, Karl, M.A., Psychology. Psychologist, Vice-President, Shailer Emery Lawton, New York, N. Y.

ACTIVE MEMBERSHIP

Alpert, Joseph, M.D., Surgery. Senior Asst. Resident, Boston City Hospital, Boston, Mass.

Berkowitz, Samuel, M.D., Medicine. Physician, Private Practice, Brooklyn, N. Y.

Bierman, Howard R., M.D., Internal Medicine. Associate Clinical Professor of Experimental Oncology, University of California Medical School, San Francisco, Calif.

Boyd, James P., Jr., B.S., Bacteriology. Bacteriologist, Wallerstein Company, Inc., Staten Island, N. Y.

Cade, Arthur R., Ph.D., Antiseptics. Bacteriologist, Givandau-Delawanna, Inc., Delawanna, N. J.

Collins, Elliott J., B.S., Endocrinology. Research Assistant, Princeton University, Princeton, N. J.

Darmstaetter, Armin A., Jr., M.D., Medicine. Surgeon, Alexander Blain Hospital, Detroit, Mich.

Demerec, M., Ph.D., Biology, Genetics. Director, Department of Genetics, Carnegie Institution, Cold Spring Harbor, N. Y.

Goldfarb, Norman, M.D., Mycology. Matriculate, Specialty Course in Dermatology & Syph. at Skin & Cancer Unit, New York, N. Y.

Green, Jack P., M.S., Pharmacology. Student, Yale University, New Haven, Conn.

Guest, C. Maynard, M.D., Arthritis. Senior Member of Professional Staff, The Northwest Clinic, Minot, N. D.

Hendelman, Solomon, M.D., Otolaryngology. Physician, Private Practice, Brooklyn, N. Y.

Holaday, Horace A., B.A., Biochemistry. Assistant Director, Manufacturing Laboratories, E. R. Squibb & Sons, New Brunswick, N. J.

Kollen, Stanley L., D.D.S., Biochemistry. Clinical Assistant, Mt. Sinai Hospital, New York, N. Y.

Kupperman, Herbert S., Ph.D., M.D., Endocrinology, Pharmacology. Research Associate, New York University Medical School, New York, N. Y.

Lan, Tien Ho, Ph.D., Biochemistry. Director, Institute of Biochemistry, Chengtu, Sezechwan, China.

Lesser, Gerson T., M.D., Medicine. Resident Physician, Goldwater Memorial Hospital, New York, N. Y.

Lewis, Hilda, B.A., Blood and Endocrine Physiology. Technical Assistant, New York University Medical College, New York, N. Y.

Moore, Ida Faye, B.A., Bacteriology. Department Head, Lederle Laboratories Division, American Cyanamid Company, Pearl River, N. Y.

Nisbett, James M., M.D., Medicine. Department of Medicine & Surgery, Veterans Administration, Little Rock, Ark.

Reddish, George F., Ph.D., Bacteriology. Director of Bacteriological Research, Lambert Pharmacal Co., St. Louis, Missouri.

Rilett, Robert O., Ph.D., Entomology, Aquatic Biology. Associate Professor of Biology, University of Buffalo, Buffalo, N. Y.

Rosenzweig, Mark R., Ph.D., Psychology. Research Fellow, Psycho-acoustic Laboratory, Harvard University, Cambridge, Mass.

Singer, Arnold J., Ph.D., Bacteriology, Pharmacology. Assistant Director of Research, Block Drug Company, Jersey City, N. J.

Smith, H. Millard, M.D., Physiology. Research Fellow, California Institute of Technology, Pasadena, Calif.

Stellar, Stanley, M.D., Biology. Neurosurgical Staff, Halloran V. A. Hospital, Staten Island, N. Y.

Tullis, James L., M.D., Cancer Research. Research Fellow, Harvard Medical School, Cambridge, Mass.

Wagner, John C., Sc.D., Virology, Immunology. Research Virologist, Camp Detrick, Frederick, Maryland.

STUDENT MEMBERSHIP

Haddad, Raef K., B.A., Psychology. Assistant in Psychology, New York University, New York, N. Y.

Pistreich, Martin L., B.S., Geology and Mineralogy. Student, Department of Geology, College of the City of New York, New York, N. Y.

Waller, Julian A., Microscopy, Zoology. Student, Columbia University, New York, N. Y.

ADDITIONS TO LIFE MEMBERSHIP CLASS BY TRANSFER

Brescia, Frank